TITLE OF INVENTION

Elevator Car Isolation System and Method

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to elevator systems. In particular, the present invention provides a method and apparatus for isolating elevator cars and platforms from vibrations.

2. Description of the Related Art

Vibrations are typically induced in elevator systems by a variety of sources. As elevator cars traverse elevator shafts, vibrations are induced by curves in the guide rails and by level differences in the guide rails. Moreover, an elevator hoist rope can transmit elevator lift motor vibrations to an elevator car. In addition, aerodynamic forces, braking forces and other mechanical sources induce a range of vibrations in an elevator system and these vibrations are often transmitted to an elevator car operating in the elevator system. In a modern elevator system, an elevator car sits on a platform that is mounted to an elevator sling. The platform is suspended from the sling by steel cables or brace rods. These cables or brace rods transmit the vibrations from the elevator system to the elevator platform and elevator car. The average power transmitted by these rods and/or cables is a function of their density, which, in the case of steel, is relatively high.

To prevent transmission of vibrational energy from the elevator system to the elevator car, most elevator manufacturers employ isolation devices, such as isolation pads, primarily manufactured from rubber, between the cables or brace rods and the elevator platform. In some applications, the platform may rest on a rubber pad that in turn rests on the elevator sling. While

rubber isolation pads are relatively inexpensive and provide some attenuation to vibrations that occur in elevator systems, they have a relatively high natural frequency. Under standard loading conditions, rubber isolation pads and rod braces have a natural frequency of about 20 Hz. Attenuating media can only attenuate vibrations whose frequencies are greater than about 1.141 times the natural frequency of the attenuating media. Thus, rubber isolation devices can only attenuate vibrations over a relatively limited range of frequencies.

SUMMARY OF THE INVENTION

The present invention provides a vibration attenuated elevator car assembly and method for isolating an elevator car from vibrations having a range of frequencies that are typically encountered in elevator systems. According to one embodiment of the present invention, a vibration attenuated elevator car assembly for attenuating elevator system vibrations is used to secure an elevator car platform to an elevator sling that travels on elevator rails in an elevator shaft. The vibration attenuated elevator car assembly comprises an elevator car platform that is horizontally suspended from the elevator sling by upper tension members and that is also secured to a lower portion of the elevator sling by lower tension members. Thus, the elevator car platform is not indirect contact with the elevator sling.

Preferably, the elevator car is isolated from elevator system vibrations by suspending the elevator car platform from an upper portion of the elevator sling with tension members manufactured from synthetic fiber because synthetic fibers transmit significantly less energy at any tension, frequency, and amplitude than steel due to their lower density. Material containing aramid fibers, such as Kevlar® rope or Kelvar® cored rope with a Nomex® sheath, is particularly

well-suited for use as a tension member because it has relatively low in-use natural frequencies. Vectran® and generic Aramid are also well-suited for use with the present invention.

As an alternative to using lower tension members, the elevator car platform may be secured to a safety plank or other lower structural member of the elevator sling with isolation mounts. In this embodiment, the car platform would still be suspended from the sling with upper tension members having an in-use natural frequency below that of the vibrations typically found in the elevator system.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a prior art elevator car isolation system.

Figure 2 illustrates a vibration attenuated car assembly according to the present invention, wherein the elevator car platform is fastened to an elevator sling with upper and lower tension members of the present invention.

Figure 3 illustrates a vibration attenuated car assembly according to the present invention, wherein the elevator car platform is fastened to an elevator sling with upper tension members of the present invention and is fixed to a lower portion of the sling with isolation mounts.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 illustrates the prior art elevator car isolation systems. Elevator platforms and cars are isolated from vibration by use of rubber isolation pads **1**. These rubber elements separate the isolated platform **4** from a structural platform **7** that is rigidly fixed to the elevator car frame. As is described in further detail below, the present invention may be used in conjunction with the prior art isolation systems or may be used alone.

As is shown in Figure 2, a elevator car platform **21** for supporting an elevator car (not shown), having a front edge **22** with a left front corner **22L** and a right front corner **22R** and back edge **23** with a left back corner **23L** and a right back corner **23R**, is suspended from an upper portion of elevator sling **24** by a plurality of upper tension members **25**, **26**, **27**, and **28**. The upper portion of the sling **24** is that portion above the elevator car platform **21**. Conversely any portion of the sling **24** below the elevator car platform **21** may be referred to as the lower portion the sling **24**. The sling **24** has a left stile **29** and right stile **30**. The left stile **29** and right stile **30** have upper portions 29A ~~**9A**~~ and 30A ~~**10A**~~, respectively, and lower portions **29B** and **30B**, respectively. A crosshead **31** spans and connects the upper portions of the stiles **29A** and **30A**. And a safety plank **32** spans the lower portions of the stiles **29B** and **30B**. A fastening plate **33** is mounted in a center portion of and under the safety plank **32**. Those skilled in the art will recognize that the crosshead **31** need not be affixed at the exact upper ends of the stiles **29** and **30** and likewise the safety plank 32 ~~**22**~~ need not be affixed at the exact bottom of the stiles **29** and **30**.

Upper tension member **25** secures the left front corner of the platform **22L** to the upper portion **29A** of the left stile **29** and is fastened to the platform **21** and stile **29** with standard fasteners. Upper tension member **26** secures the right front corner of the platform **22R** to the upper portion **30A** of the right stile **30** and is fastened to the platform **21** and stile **30** with standard fasteners. Upper tension member **27** secures the left back corner of the platform **23L** to the upper portion **29A** of the left stile **29** and is fastened to the platform **21** and the stile **29** with standard fasteners. Upper tension member **28** secures the right back corner of the platform **23R** to the upper portion **30A** of the right stile **30** and is fastened to the platform **21** and the stile **30** with standard fasteners.

In addition to being suspended from the upper portions **29A** and **30A** of the stiles **29** and **30** of the elevator sling **24**, the elevator car platform **21** may also be secured to the safety plank **22** 32 by a plurality of lower tension members. Lower tension member **34** secures the right front corner of the platform **22R** to a fastening plate **33** and may be fastened to the fastening plate **33** and the platform **21** with standard fasteners. Lower tension member **35** secures the left front corner of the platform **22L** to the fastening plate **33** and may be fastened to the fastening plate **33** and the platform **21** with standard fasteners. Lower tension member **36** secures the right back corner of the platform **23R** to the fastening plate and may be fastened to the fastening plate **33** and the platform **21** with standard fasteners. A fourth lower tension member (not shown) secures the left back corner of the platform **23L** to the fastening plate **33** and may be fastened to the fastening plate **33** and the platform **21** with standard fasteners. The upper and lower tension members may, but need not, be fastened to the exact corners of the elevator car platform **21**. The upper and lower tension members may be fastened to the platform **21** in any manner that provides adequate support for the platform **21**.

The upper and lower tension members are preferably made of a material having a low ability to transmit power and have a low in-use natural frequency, preferably below the frequency of vibrations found in an elevator system, which is typically between 4 and 8 Hz. In general, the average power that can be transmitted is defined by the following equation:

$$\overline{P} = \frac{1}{2}\mu \upsilon \omega^2 y_m^2$$

Where density $\mu = \frac{m}{l}$ $\quad m = \text{mass} \quad l = \text{length}$.

Where Wave velocity $\upsilon = \sqrt{\frac{\text{tension}}{\mu}}$

Where frequency and amplitude are represented by ω & y.

Cable or rope containing aramid fibers, such as Kevlar® rope or Kevlar® cored rope having a fire resistant sheath made from a material, such a Nomex,® or a fire resistant coating, is particularly well-suited for use as a tension member because it has a low density. Spectra, graphite and fiberglass ropes or other composites structures may also be used as tension members. The ropes or cables that form tension members may comprise woven, bundled, or twisted fibers, and may in some, but not all embodiments, be covered with a sheath. Tension members should be sufficiently strong and stiff to support a fully loaded elevator car. Preferably, but not necessarily, the tension members should have a working load of 3000 pounds or greater. Often this requires the use of an aramid fiber rope having a 0.5 inch or greater diameter. The tension members should have a strength and a working load rating substantially equivalent to 5/8 inch diameter steel rods, which are typically used to suspend elevator car platforms. Typically, the upper tension members of the present invention are about 2 meters long. In some embodiments, it may be desirable to have tension members having a density of less than about 7.7 grams per cubic centimeter ("g/cc") and preferably less than 2.5 g/cc. In one embodiment, where 0.5 inch diameter Kevlar® 49 sheathed rope is used, the tension members preferably have a linear mass density of about 0.138 kilograms per meter of length. In some situations, it may be advantageous to use different material for the upper and lower tension members. Likewise, the strength and other physical properties of the upper and lower tension members do not necessarily have to be identical and in certain situations better attenuation might be achieved by using upper tension members that have different properties than the lower tension members.

While the embodiment of the present invention described in the above example employs four upper tension members and four lower tension members, those of skill in the art will appreciate that the number and placement of the tension members may be varied depending upon other design criteria. Moreover, while it is often preferable to use materials for the tension members that cause the tension members to have low natural frequencies – to attenuate a large range of frequencies – it may, depending upon the frequency of vibrations that are to be attenuated, be desirable to use tension members having high, medium, low or ultra low natural frequencies. Likewise, the density of the tension member may vary.

As is shown in Figure 3, an alternative embodiment of the present invention employs four upper tension members **25**, **26**, **27**, and **28** to suspend the platform **21** from the right and left stiles **29** and **30** of the elevator sling. Upper tension members **25**, **26**, **27**, and **28** are made from aramid fiber rope, such as Kevlar® cored rope and may be secured to the platform with standard means, such as isolation anchors **42**. The upper tension members **25**, **26**, **27**, and **28** should have a low in-use natural frequency, preferably a frequency below that of vibrations found in an elevator system. The platform **21** rests on platform isolation pads **40** that are mounted to the top of the safety plank **32**. In addition, the platform is secured to the stiles **29** and **30** with stile isolation pad and retainer brackets **41**.

The isolation pads and isolation anchors that may be used with the present invention may be standard rubber isolation pads, or they may be pads manufactured from other materials, including aramid fibers, that are inefficient at transmitting energy.

The present invention may be used in standard elevator systems, including roped and hydraulic systems, and in elevator systems that employ synthetic fiber hoist ropes, which also help dampen vibrations transmitted from the elevator system to elevator cars in the system.